ANALOG DEVICES

Interface and Supervisory Circuits

ISSUE 4 June, 1996

Technical Information

Dial into our 24-hour automated literature delivery system and get a fax back of up to five data sheets

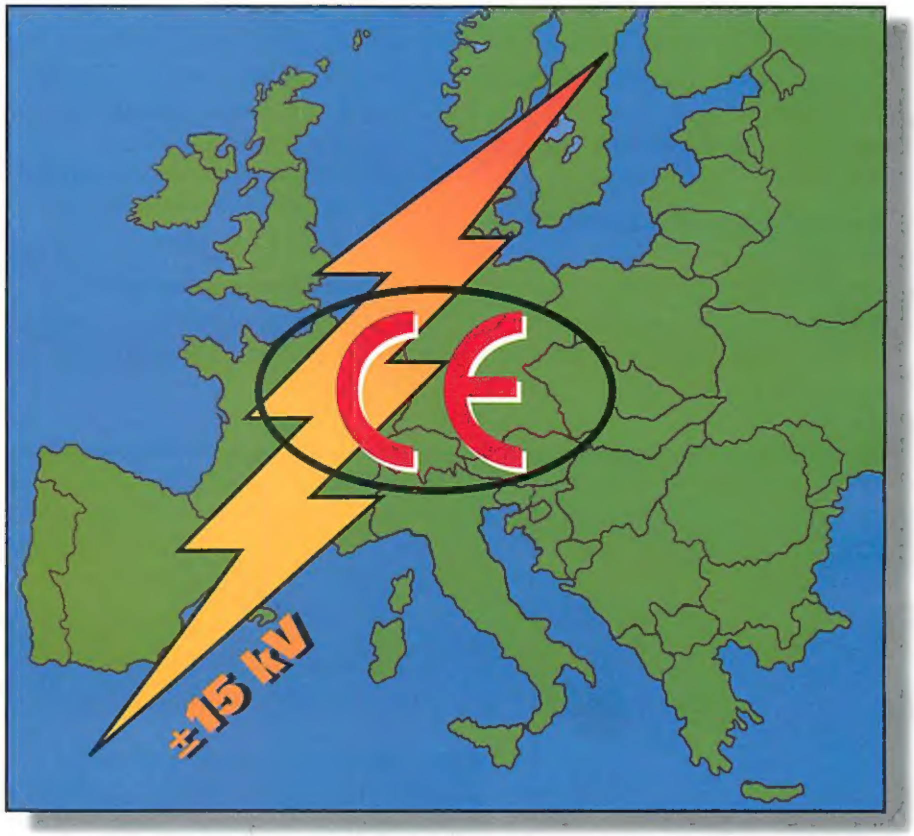
AnalogFax™
1-800-446-6212

For Additional Information Call 1-800-ANALOGD (262-5643)†, or visit us on the World Wide Web

http://www.analog.com

†Outside the U.S., please call 617-461-3392

The First RS-232 Transceivers To Meet European EMI and ESD Requirements



The ADM202E, ADM207E, ADM208E, ADM211E and ADM213E are the industry's first family of robust, RS-232 and V.28 interface transceivers which meet and exceed the stringent European Union (EU) directive on electromagnetic compatibility. Each provides ±15 kV of ESD protection and compliance with EMI/EMC requirements.

The regulations demand that products for sale in the EU "be so constructed that they do not cause excessive electromagnetic interference and are not unduly affected by electromagnetic interference". It is expected that the EU standards will be adopted worldwide.

Conformance with the directive on electromagnetic compatibility requires that products must have a high level of intrinsic immunity to emissions from other sources, and must also limit their undesirable emissions to within very strict limits. Enclosed is general design information on the new IEC requirements which you'll want to keep on file.

You'll also learn how you can enable your interface designs and systems to be marketed in Europe with the new Analog Devices' ADM2xxE family of standards-compliant transceivers.

Analog Devices' new family of RS-232 transceivers opens you to the European market and provides your interface designs and systems with unmatched ruggedness.

Setting New Standards of Compliance

Every member of the ADM2xxE family is designed and tested to ensure the highest level of intrinsic immunity. On-chip ESD, EFT and EMI protection structures comply with IEC1000-4-2, IEC1000-4-3 and IEC1000-4-4 requirements. You're protected against Electrostatic Discharges to ±15 kV and Electrical Fast Transients to ±2 kV. Added benefits include latch-up protection and immunity to high RF field strengths, allowing operation in unshielded enclosures.

Maintaining System-Level Advantages

Despite all this protection, the ADM2xxE family doesn't sacrifice high speed. Fast slew rates coupled with low propagation delay specifications permit data transmission up to 230 kbps under heavy capacitive loading. You're getting high LapLink®-compatible speed from a single +5 V supply and lowest-in-industry power consumption. The ADM211E and ADM213E also feature a shutdown function with power consumption less than 5 µW in the sleep mode.

Cost and Space Savings

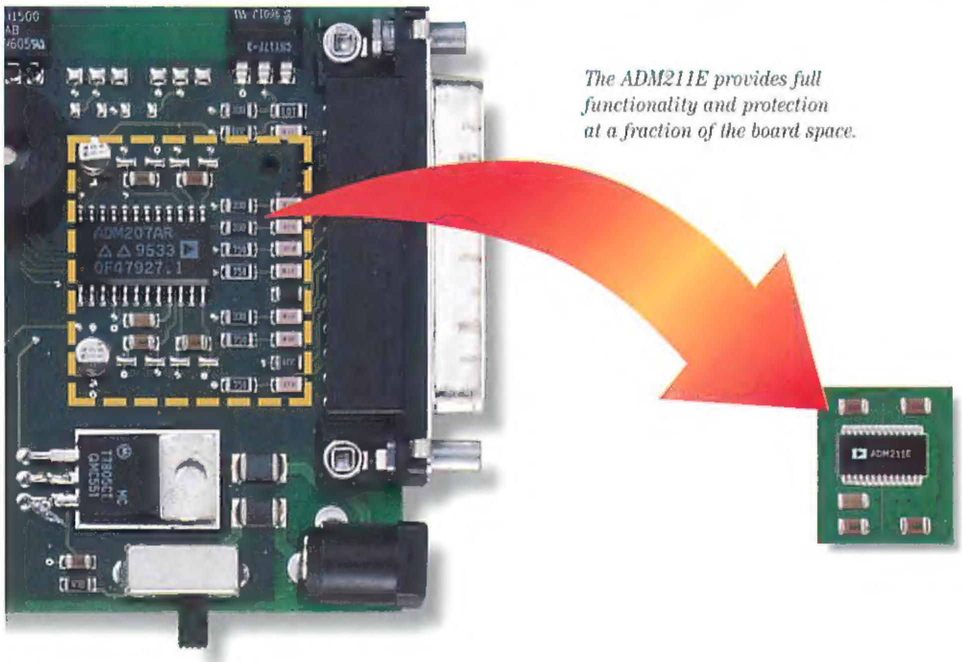
Design out costly external protection and filtering schemes by designing in ADM2xxE family members. Conducted and radiated emissions will still meet EN55022, CISPR22 requirements for Information Technology Equipment (ITE) while you reduce system cost and save valuable board space. Now there's no need for high-frequency suppression filters, shielding components and filtered connectors. Fewer parts means higher reliability in TSSOP and other packaging with small (0.1 µF) capacitors.

Figure 1: Typical PC RS-232 application

Table 1

PRODUCT SELECTION TABLE

Model	Drivers	Receivers	ESD Protection	Shutdown	# Receivers Active In Shutdown	Enable	Packages	Applications
ADM202E	2	2	±15 kV	No	—	No	DIP, SOIC, SSOP, TSSOP	General Purpose
ADM207E	5	3	±15 kV	No	—	No	DIP, SOIC, SSOP, TSSOP	Modem
ADM208E	4	4	±15 kV	No	—	No	DIP, SOIC, SSOP, TSSOP	Printer
ADM211E	4	5	±15 kV	Yes	0	Yes	SOIC, SSOP, TSSOP	Notebook, Laptop, PDA
ADM213E	4	3	±15 kV	Yes	2	Yes	SOIC, SSOP, TSSOP	Notebook, Laptop, PDA



The ADM211E provides full functionality and protection at a fraction of the board space.

The European Union EMC Directive

In May, 1989, the European Union published the 89/336/EEC Council Directive relating to electromagnetic compatibility of products placed on the market within the member states. This was followed by the 92/31/EEC amendment which delayed compulsory compliance until January 1, 1996. The directive applies to apparatus which is liable to cause electromagnetic disturbance or which itself is liable to be affected by such disturbance. Therefore, it applies to all electrical or electronic products. It goes beyond the FCC Class B requirement for emissions control since it also addresses immunity requirements.

Conformance with the EU directive on electromagnetic compatibility requires that products will:

- have a high level of intrinsic immunity to emissions from other sources
- limit their undesirable emissions to within very strict limits

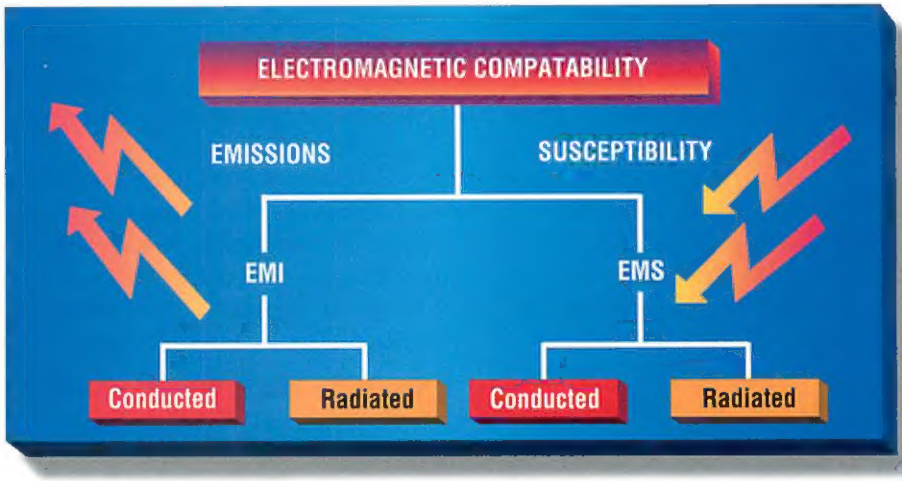


Figure 2: Electromagnetic compatibility

Table 2

Previous Standard	Current Standard	Section
IEC801	IEC1000-4	Electromagnetic Compatibility (EMC)
IEC801-1	IEC1000-4-1	Overview of Immunity Tests
IEC801-2	IEC1000-4-2	Electrostatic Discharge Immunity (ESD)
IEC801-3	IEC1000-4-3	Radiated Radio-Frequency Electromagnetic Field Immunity
IEC801-4	IEC1000-4-4	Electrical Fast Transients (EFT)

Basic IEC1000-4 immunity standards

The CE mark

The CE Mark

Responsibility to meet the regulations lies with the product manufacturer. Since January 1, 1996, electronic products sold in the EU must conform to the directive by displaying the Communaute Europeene (CE) marking. Use of the CE mark indicates that the equipment complies with the directive.

Standards

The standards to which a product must comply in order to achieve the CE mark fall into four categories: product standards; product family standards; generic standards; and basic standards. A product should be tested to its product standard if one exists. If not, it must be tested to the appropriate product family standard, or if this does not exist, the generic standard is applied.

Basic standards describe the phenomenon, specify the test equipment and detail the test setup and methodology. The basic standards applying to EMC immunity are IEC1000-4-x.

The immunity specification contained in the EU directive includes electrostatic discharge (ESD) testing. IEC1000-4-2 (previously IEC801-2) specifies compliance testing using two coupling methods, contact discharge and air–gap discharge. Contact discharge calls for a direct connection to the unit being tested. Air–gap discharge uses a higher test voltage but does not make direct contact with the unit under test. With air–gap, the discharge gun moves toward the unit under test, developing an arc across the air gap. Hence, the term "air–gap". This method is influenced by humidity, temperature, barometric pressure, distance and rate of closure of the discharge gun. The contact-discharge method, while less realistic, is more repeatable and is gaining acceptance over the air–gap method.

Although very little energy is contained within an ESD pulse, the extremely fast rise time – coupled with high voltages – can cause failures in unprotected semiconductors. Catastrophic destruction can occur immediately as a result of arcing or heating. Even if catastrophic failure does not occur immediately, the device may suffer from parametric degradation, which may result in degraded performance. The cumulative effects of continuous exposure can eventually lead to complete failure.

I/O lines are particularly vulnerable to ESD damage. Simply touching or plugging in an I/O cable can result in a static discharge, causing potential damage or complete destruction of the interface product connected to the I/O port.

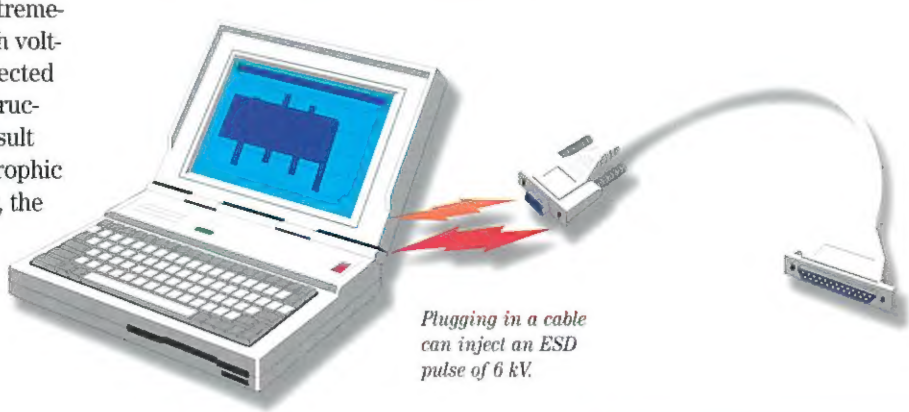
MIL-STD 883B Test Method

Traditional ESD test methods, such as the MIL-STD 883B human-body model (method 3015.7) used by most semiconductor manufacturers, do not adequately test a product's susceptibility to this type of real-world discharge. The traditional test was intended to evaluate a product's susceptibility to ESD damage during handling and board manufacture. Each pin is tested with respect to all other pins, simulating the type of discharges likely to occur during handling or with auto insertion equipment. There are some important differences between the traditional test and the IEC test. These differences are explained on page 3.

Table 3

ESD Test Method	R2	C1
MIL-STD 883B	1.5 kΩ	100 pF
IEC1000-4-2	330 Ω	150 pF

ESD discharge component values



Plugging in a cable can inject an ESD pulse of 6 kV.

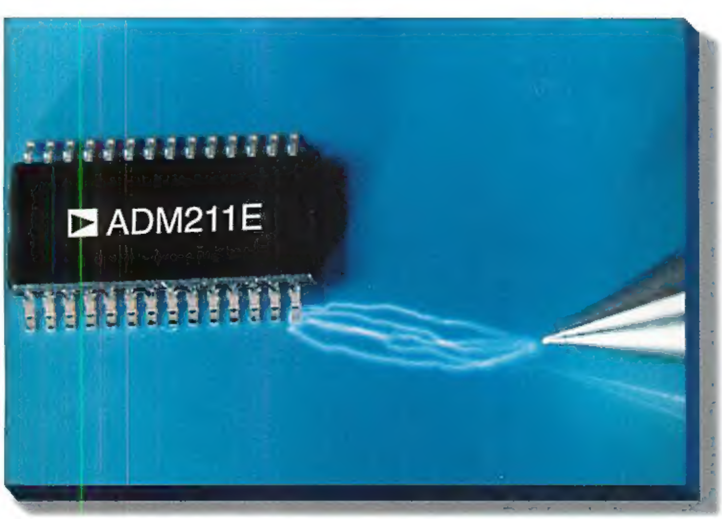


Figure 3: 15 kV electrostatic discharge in ADM211E

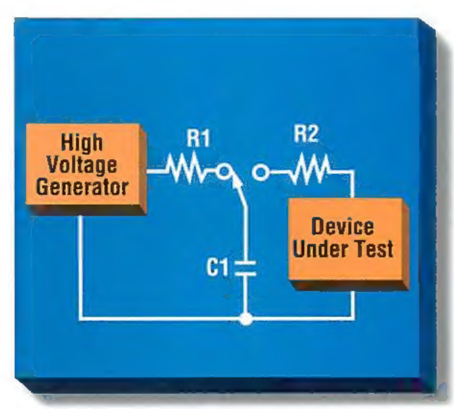


Figure 4: ESD test generator

IEC1000-4-2 vs. MIL-STD 883B

The IEC test is much more stringent in terms of discharge energy. Figure 4 shows a simplified schematic of the ESD test generator. Capacitor C1 is charged up to the required test voltage via R1. The energy in C1 is then discharged via R2 into the device under test. The peak current and discharge energy is determined by R2 and C1. Table 3 shows that for the IEC test, R2 is decreased from 1.5 kΩ to 330 Ω. This results in greater than 4X peak current increase. In addition, C1 increases by 50% from 100 pF to 150 pF.

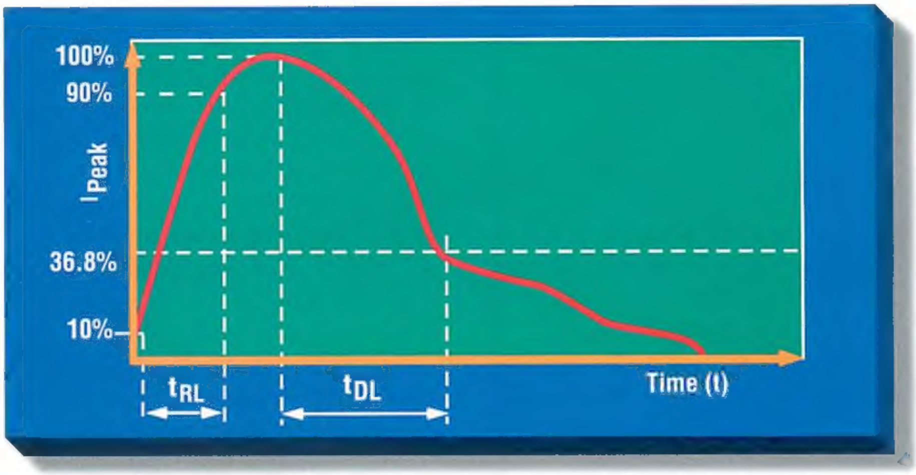


Figure 5: Human body model discharge current waveform

Table 4

Level	Max Charge Voltage (kV)	Contact Discharge (kV)	Air Discharge (kV)
1	2	2	2
2	4	4	4
3	8	6	8
4	15	8	15

IEC1000-4-2 severity levels and test voltages

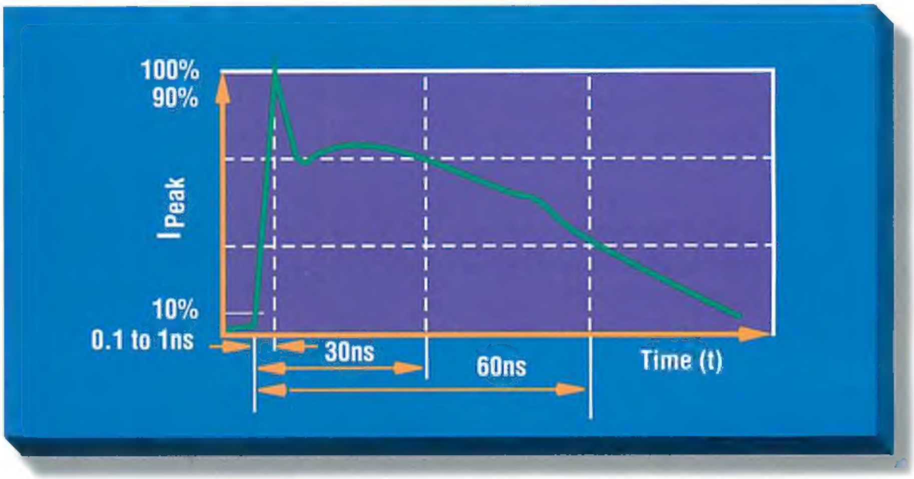


Figure 6: IEC1000-4-2 contact discharge current waveform

The IEC1000-4-2 test is carried out while power is applied to the device. This is unlike the MIL-STD 883B test where power is not applied. The process, therefore, checks for potential destructive latch-up which could be induced by the ESD transient. (It applies to I/O pins only.)

The IEC test is more representative of a real-world I/O discharge where the equipment is operating normally with power applied. For maximum peace of mind, however, both tests should be performed to ensure maximum protection in handling, manufacturing and later during field service.

ESD Testing Methods

The ADM2xxE family of products is tested using both the abovementioned test methods. All pins are tested with respect to all other pins per the MIL-STD 883B specification. In addition, all I/O pins are tested per the IEC test specification.

Table 4 shows the four levels of compliance defined by IEC1000-4-2. The ADM2xxE family meets the most stringent compliance level for both contact and air–gap discharge. This means that the products are able to withstand contact discharges up to 8 kV and air–gap discharges up to 15 kV.

Table 5

ESD Test Method	I/O Pins	Other Pins
MIL-STD 883B	15 kV	2.5 kV
IEC1000-4-2		
Contact	8 kV	-
Air	15 kV	-

ADM2xxE ESD results

Fast Transient Burst Immunity

IEC1000-4-4 (previously IEC801-4) covers electrical fast transient burst (EFT) immunity. Electrical fast transients occur as a result of arcing contacts in switches and relays. The tests defined in IEC1000-4-4 simulate the interference generated when, for example, a power relay disconnects an inductive load. A spark is generated due to the well-known back EMF effect. There is actually a burst of sparks as the relay contacts separate. The voltage appearing on the line consists of extremely fast transient bursts.

The fast transient burst test defined in IEC1000-4-4 attempts to simulate the interference resulting from this type of event and its waveform is illustrated in Figure 7. The waveform consists of a burst of 2.5 kHz to 5 kHz transients repeating at 300 ms intervals. These transients are coupled onto the I/O lines using a 1 meter capacitive clamp. Voltages as high as 2 kV are applied with fast transition times as illustrated in Figure 7. This can immediately destroy the integrated circuit connected to the I/O line or cause degradation in performance with delayed failure. The ADM2xxE uses a protection scheme designed to clamp the overvoltages to safe levels. This test is extremely severe since a combination of high voltages and fast edges merge onto the signal lines. In addition, the repetitive transients can often cause problems where single pulses do not. Destructive latch-up may be induced due to the high energy content of the transients. Note that the transients are applied while the interface products are powered up and are transmitting data. The EFT test applies hundreds of pulses with higher energy than ESD. In the worst case, transient current on an I/O line can be as high as 40 A. Test results are classified accordingly:

1. normal performance within specification limits
2. temporary degradation or loss of performance which is self-recoverable
3. temporary degradation or loss of function or performance which requires operator intervention or system reset
4. degradation or loss of function which is not recoverable due to damage

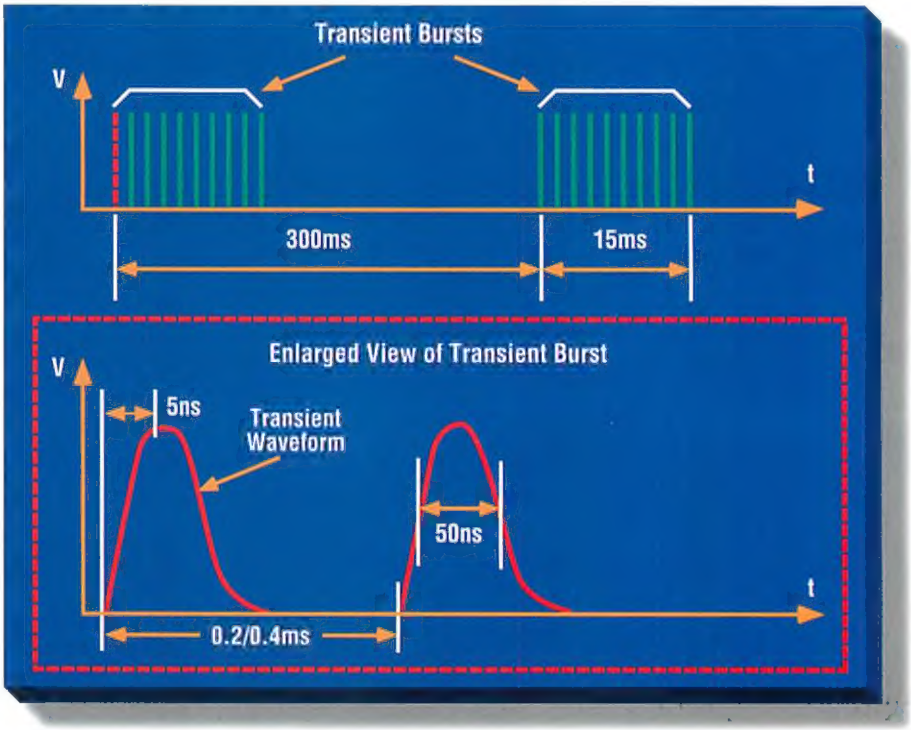


Figure 7: IEC1000-4-4 fast transient waveform

Test Results

The ADM2xxE products were tested under worst-case conditions using unshielded cable. Data transmission during the transient condition was corrupted, but it recovered immediately following the EFT event without user intervention. No damage or latch-up occurred even with voltages in excess of the specification requirements.

Electromagnetic Fields

IEC1000-4-3 (previously IEC801-3) describes the measurement method and defines the levels of immunity to radiated electromagnetic (EM) fields. It was originally intended to simulate the electromagnetic fields generated by portable radio transceivers or any other device which generates continuous wave-radiated electromagnetic energy. Its scope has since been broadened to include spurious EM energy, which can be radiated from fluorescent lights, thyristor drives, inductive loads, etc.

Testing for immunity involves irradiating the device with an EM field. There are various methods of achieving this. Testing integrated circuits is most conveniently achieved using some form of stripline cell. This device cell consists of two parallel plates with an electric field developed between them. A high-power RF amplifier generates the field which is swept in frequency from 80 MHz to 1 GHz. The device under test is placed within the cell and exposed to the electric field. A field strength monitor within the cell regulates the field strength, providing feedback so that constant field level versus frequency is maintained. There are three severity levels defined with field strengths ranging from 1 V/m to 10 V/m. Results are classified in a similar fashion to those for IEC1000-4-4:

1. normal operation
2. temporary degradation or loss of function which is self-recoverable when the interfering signal is removed
3. temporary degradation or loss of function which requires operator intervention or system reset when the interfering signal is removed
4. degradation or loss of function which is not recoverable due to damage

Table 6

Level	Field Strength (V/m)
1	1
2	3
3	10

EM classification levels

Test Results

The ADM2xxE family of products was tested at field strengths up to 30 V/m and showed no performance degradation. Error-free data transmission continued even during irradiation.

Common source of radiated noise

INTERNAL PROTECTION SCHEME ON RS-232 I/O LINES

ESD/EFT Transient Protection*

The ADM2xxE uses protective clamping structures on all inputs and outputs, which holds the voltage to a safe level and dissipates the energy present in ESD (Electrostatic) and EFT (Electrical Fast Transient) discharges. A simplified schematic of the protection structure is shown in Figure 8. Each RS-232 I/O line contains two back-to-back high-speed clamping diodes. During normal operation with maximum RS-232 signal levels, the diodes have no effect as one or the other is reverse-biased depending on the polarity of the signal. If, however, the voltage exceeds approximately ±50 V, reverse breakdown occurs and the diodes begin conducting. The voltage is therefore clamped at this level. The diodes are large p-n junctions designed to handle the instantaneous current surge which can exceed several amperes.

The transmitter outputs and receiver inputs have a similar diode protection structure. The receiver inputs can also dissipate some of the energy through an internal 5 kΩ resistor to GND as well as through the protection diodes. The protection structure achieves ESD protection up to ±15 kV and EFT protection up to ±2 kV on all RS-232 I/O lines. Latch-up protection in accordance with JEDEC Standard 17 is also achieved.

** Patent Pending*

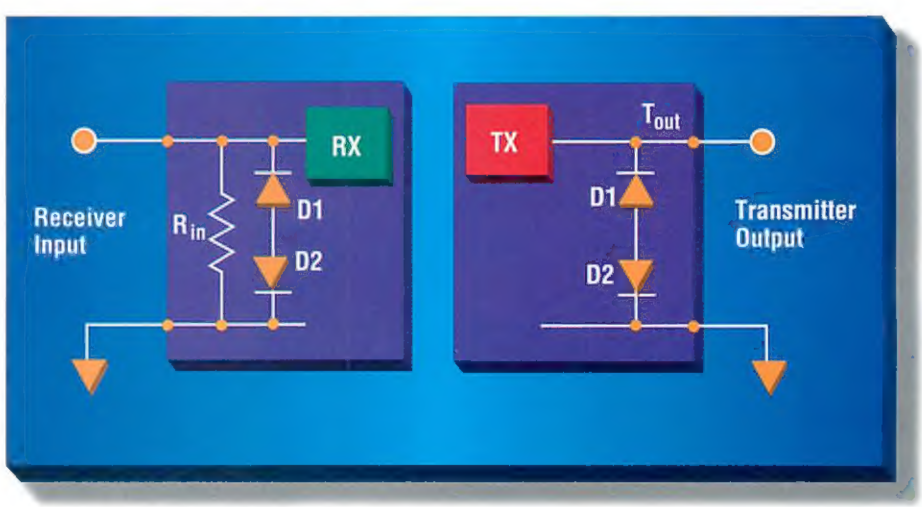
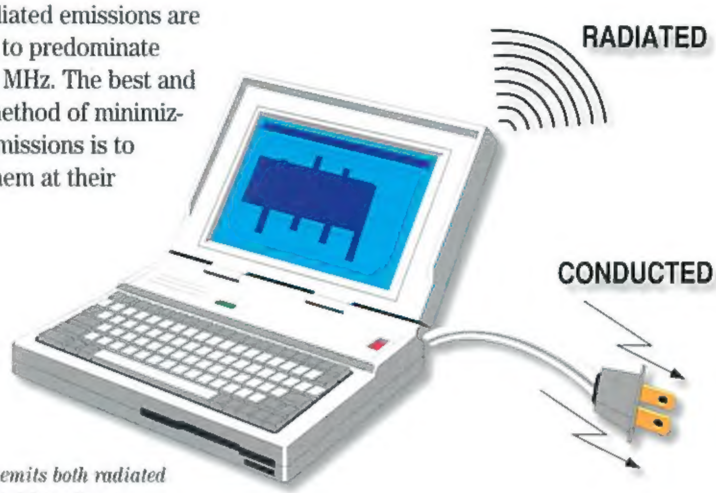


Figure 8: Internal protection structure

Emissions/Interference

EN55022, CISPR22 define the permitted limits of radiated and conducted interference from Information Technology (IT) equipment. The objective of the standard is to minimize the level of emissions both conducted and radiated.

Any circuit where there are switching signals will emit electromagnetic energy. High-frequency current transients can cause both conducted and radiated emissions. For ease of measurement and analysis, conducted emissions are assumed to predominate below 30 MHz while radiated emissions are assumed to predominate above 30 MHz. The best and easiest method of minimizing the emissions is to reduce them at their source.



Equipment emits both radiated and conducted interference.

Radiated Emissions

Radiated emissions are measured at frequencies in excess of 30 MHz. RS-232 outputs, designed for operation at high baud rates while driving unshielded cables, can radiate high-frequency electromagnetic energy. In fact, emissions can start out being conducted on the power supply lines and become radiated if the frequency components are sufficiently high.

Fast RS-232 output transitions can radiate interference – especially when lightly loaded and driving unshielded cables. Charge-pump devices are also prone to radiating noise due to the high-frequency oscillator and high voltages being switched by the charge pump. The move to conserve board space with smaller capacitors has resulted in employment of higher frequency oscillators in the charge pump design. This causes higher levels of both conducted and radiated emissions.

The ADM2xxE products feature RS-232 outputs with a controlled slew rate in order to minimize the level of radiated emissions. However, they are fast enough to support data rates up to 230 kBaud.

Figure 9 shows a plot of radiated emissions vs. frequency. This shows that the levels of emissions are well within specifications without the need for any additional shielding or filtering.

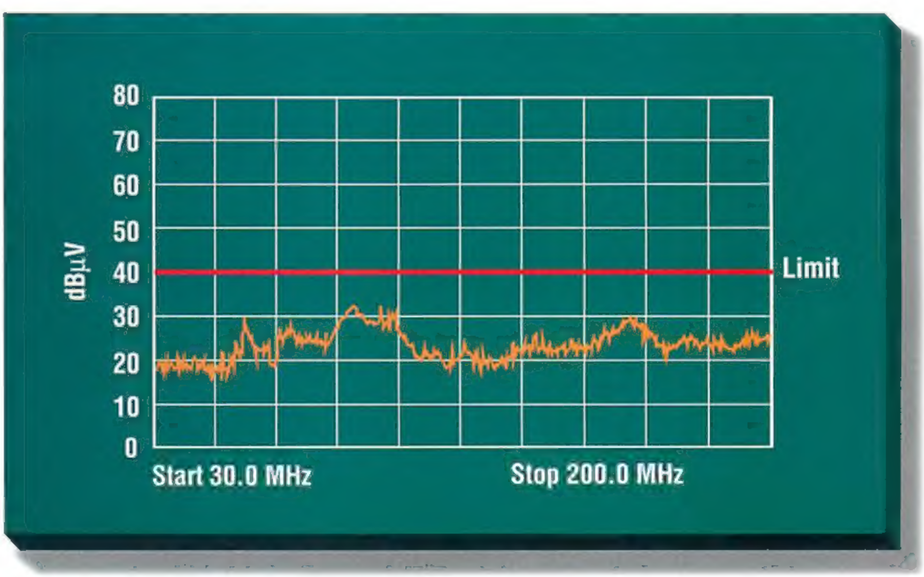


Figure 9: Radiated emissions frequency plot

Conducted Emissions

This is a measure of noise which gets conducted back onto the main power supply. In charge-pump based products, switching transients from the charge pump, which are 20 V in magnitude and containing significant energy, will result in conducted emissions. Emissions can also result from overlap in switch on-times in the charge pump voltage converter. As shown in the voltage doubler schematic (Figure 12), if S2 has not fully turned off before S4 turns on, the result is a transient current glitch between V_{CC} and GND which leads to conducted emissions. This process makes it important that the switches are carefully timed to ensure break-before-make switching under all operating conditions. Now instantaneous short-circuit conditions will not occur.

Figure 11 shows a typical plot of the conducted noise emitted by the ADM2xxE. The frequency components resulting from the charge pump switching are clearly visible, but careful design makes sure that they are well below the maximum specification levels.

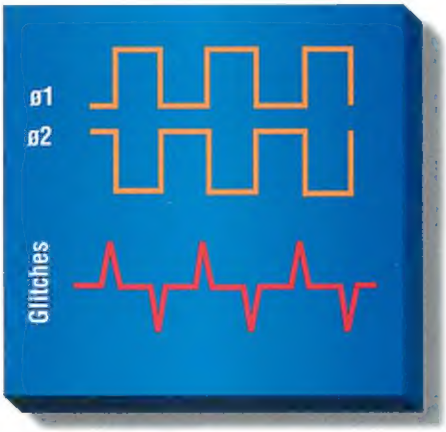


Figure 10: Charge pump switching glitches

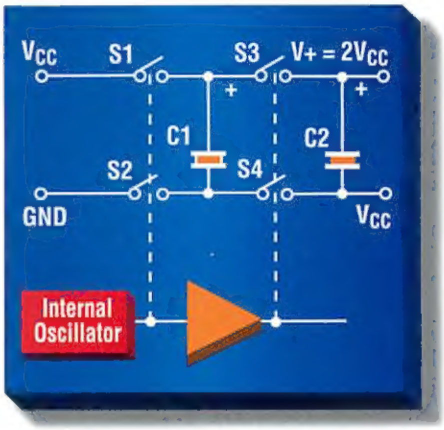


Figure 12: Charge pump voltage doubler

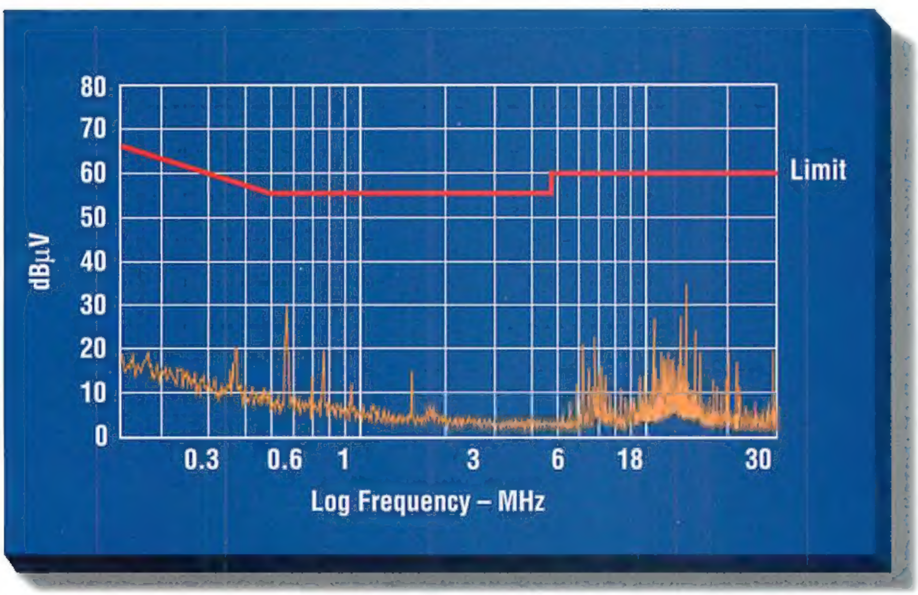


Figure 11: Conducted emissions frequency plot

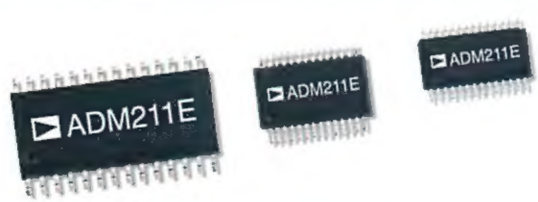
CROSS REFERENCE CHART

ADI			ADI Faxcode	ADI			ADI Faxcode	ADI			ADI Faxcode
ADM202	LT1181	MAX202	1528	ADM232L	LT1081	MAX232	1540	ADM690	LTC690	MAX690	1562
ADM202E		MAX202E	1992	ADM232A	LT1181A	MAX232A	1539	ADM691	LTC691	MAX691	1563
ADM203		MAX203	1529	ADM233L		MAX233	1540	ADM692	LTC692	MAX692	1564
ADM206		MAX206	1531	ADM234L		MAX234	1540	ADM693	LTC693	MAX693	1565
ADM207		MAX207	1532	ADM236L		MAX236	1540	ADM694	LTC694	MAX694	1566
ADM207E			1991	ADM237L		MAX237	1540	ADM695	LTC695	MAX695	1567
ADM208		MAX208	1533	ADM238L		MAX238	1540	ADM696		MAX696	1568
ADM208E			1991	ADM239L		MAX239	1540	ADM697		MAX697	1569
ADM209		MAX209	1534	ADM241L		MAX241	1540	ADM698		MAX698	1570
ADM211		MAX211	1536	ADM242		MAX242	1552	ADM699	LTC699	MAX699	1571
ADM211E		MAX211E	1991	ADM485	LTC485	MAX485	1553	ADM705		MAX705	1865
ADM213E		MAX213E	1991	ADM560		MAX560	1556	ADM706		MAX706	1865
ADM222	LT1180	MAX222	1539	ADM561		MAX561	1557	ADM707		MAX707	1865
ADM223		MAX223	1540	ADM660	LTC1046	MAX660	1934	ADM708		MAX708	1865
ADM230L		MAX230	1540	ADM660	LTC1044	MAX1044		ADM709		MAX709	1893
ADM231L		MAX231	1540	ADM660		MAX7660		ADM1485	LTC1485		1527

ADM2xxE PACKAGING AND PRICING

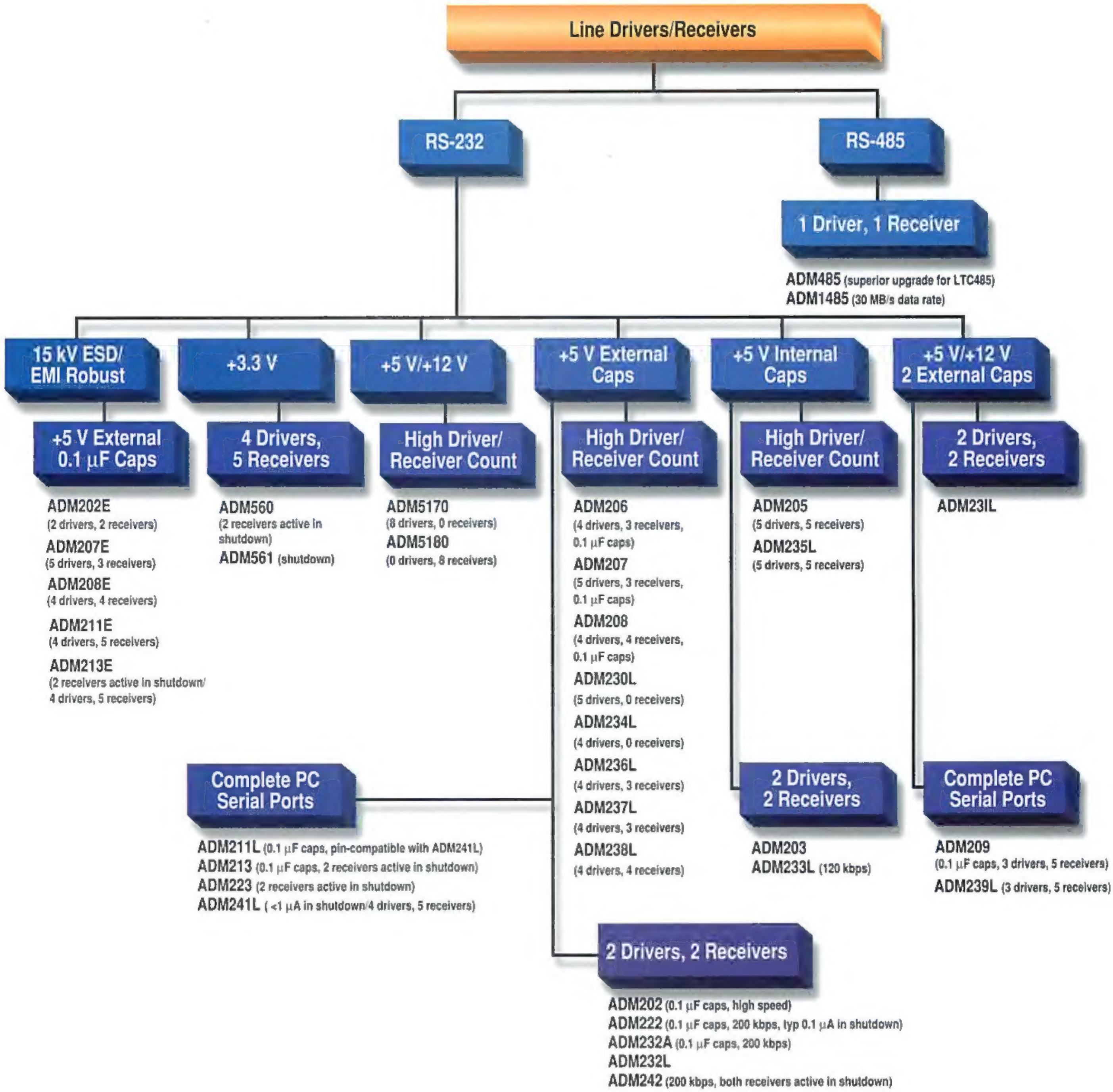
Packaging and Pricing

The ADM2xxE family is available in a variety of packages including DIP, SOIC, SSOP and TSSOP. SSOP gives a space savings of 57% over SOIC while TSSOP results in a further 28% saving. The TSSOP also saves on package height by 45%. Pricing begins at $1.40, recommended resale, in 1,000 lot quantities, FOB U.S.A.



SOIC, SSOP, TSSOP packaging

SELECTION TREE



Sales Directory

North American Sales Offices and Representatives

Alabama: *205-534-2414
Alaska: *206-575-6344, *714-641-9391
Arizona: *714-641-9391, *602-840-7258
Arkansas: *214-231-5094
California: *714-641-9391, *408-559-2037
Colorado: *714-641-9391
Connecticut: *203-740-8687
Delaware: *215-643-7790
Florida: *407-660-8444
Georgia: *770-497-4440
Hawaii: *714-641-9391
Idaho: *714-641-9391
Illinois: *847-519-1777
Indiana: *219-489-3083
Iowa: *319-377-7497
Kansas: *314-839-1465
Kentucky: *770-497-4440
Louisiana: *214-231-5094
Maine: *617-461-3000
Maryland: *215-643-7790
Massachusetts: *617-461-3000
Michigan: 810-615-4000, *810-348-5795
Minnesota: 612-835-9234
Mississippi: *770-497-4440
Missouri: *314-839-1465
Montana: *714-641-9391
Nebraska: *314-839-1465
Nevada: *408-559-2037, *714-641-9391
New Hampshire: *617-461-3000
New Jersey: *516-366-0765 (north), *215-643-7790 (south)
New Mexico: *714-641-9391, *602-840-7258
New York: *617-461-3000
North Carolina: *770-497-4440
North Dakota: *612-835-9234
Ohio: *216-247-0060, 513-742-8447, 614-487-1882
Oklahoma: *214-231-5094
Oregon: *206-575-6344
Pennsylvania: *215-643-7790
Rhode Island: *617-461-3000
South Carolina: *770-497-4440
South Dakota: 612-835-9234
Tennessee: *770-497-4440
Texas: *214-231-5094
Utah: *1-800-626-5645
Vermont: *617-461-3000
Virginia: *215-643-7790
Washington: *206-575-6344
West Virginia: 412-745-8441
Wisconsin: *847-519-1777
Wyoming: *714-641-9391
Puerto Rico: *809-753-9811
Canada: 905-821-7800, 613-564-0014, 514-697-0801, 604-465-6892
Mexico: *617-461-3000

*Analog Devices, Inc., Direct Sales Offices

North American Distributors

Allied Electronics 800-433-5700
Bell Industries 800-289-2355
Chip Supply 407-298-7100
Future Electronics 800-388-8731
Hamilton Hallmark 800-332-8638
Newark Electronics 800-367-3573
Pioneer 800-227-1693
Semi Dice 714-952-2216
Wyle 800-414-4144

EUROPE HEADQUARTERS
Edelsbergstraße 8-10, 80686 München, Germany; Tel: 089/57 005-0; Fax: 089/57 005-257

JAPAN HEADQUARTERS
New Pier Takeshiba, South Tower Building, 1-16-1 Kaigan, Minato-ku, Tokyo 105, Japan; Tel: (3) 5402-8210; Fax: (3) 5402-1063

SOUTHEAST ASIA HEADQUARTERS
2102 Nat West Tower, Times Square, One Matheson Street, Causeway Bay, Hong Kong; Tel: (2) 506-9336; Fax: (2) 506-4755

WORLDWIDE HEADQUARTERS
One Technology Way, P.O. Box 9106, Norwood, MA 02062-9106, U.S.A.
Tel: (617) 329-4700, (1-800) 262-5643 (U.S.A. only); Fax: (617) 326-8703

http://www.analog.com

ANALOG DEVICES
Analog. Digital. Solutions.

PRINTED IN U.S.A.
G2146–35–6/96